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(54) **RADIO-OVER-FIBER (ROF) SYSTEM FOR PROTOCOL-INDEPENDENT WIRED AND/OR WIRELESS COMMUNICATION**

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See application file for complete search history.

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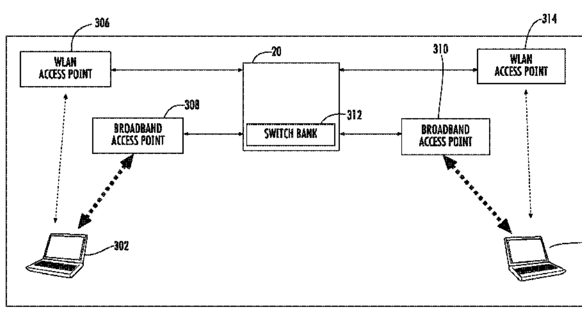
(57) **ABSTRACT**

A switched wireless system is used to increase the range of peer-to-peer communications. The optically-switched fiber optic communication system includes a head-end unit (HEU) having a switch bank. Cables couple the HEU to one or more remote access points in different coverage areas. The switch bank in the HEU provides a link between the remote access points in the different coverage areas such that devices in the different cellular coverage areas communicate with each other, such as through videoconferencing. By using the switched communication system, the range and coverage of communication between devices may be extended such that devices in different coverage areas and devices using different communication protocols can communicate.

17 Claims, 11 Drawing Sheets



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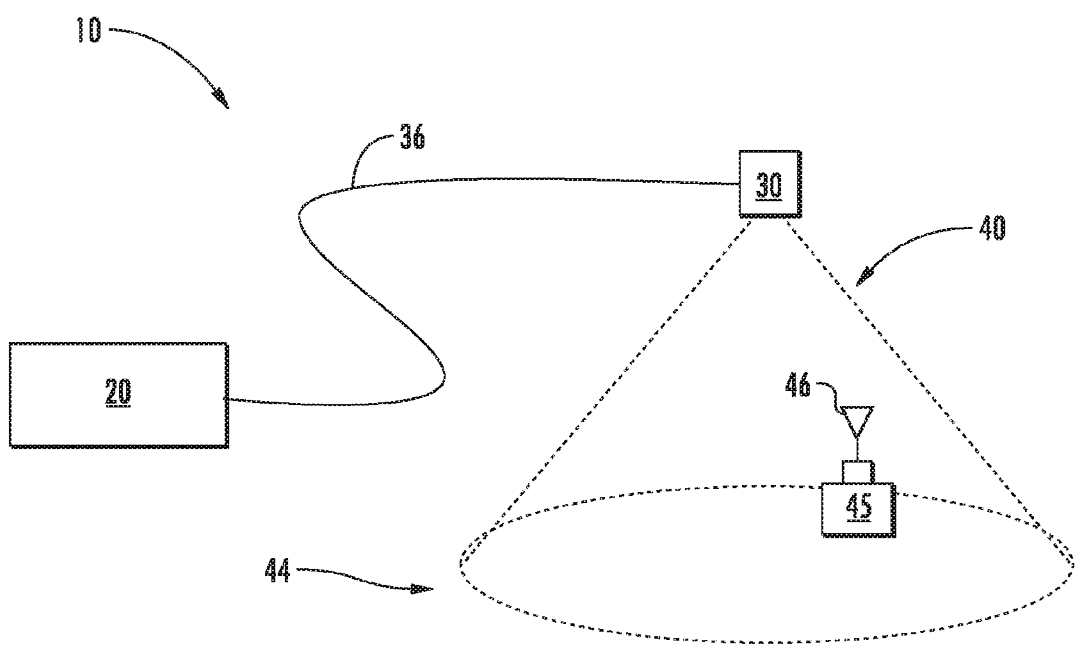

FIG. 1

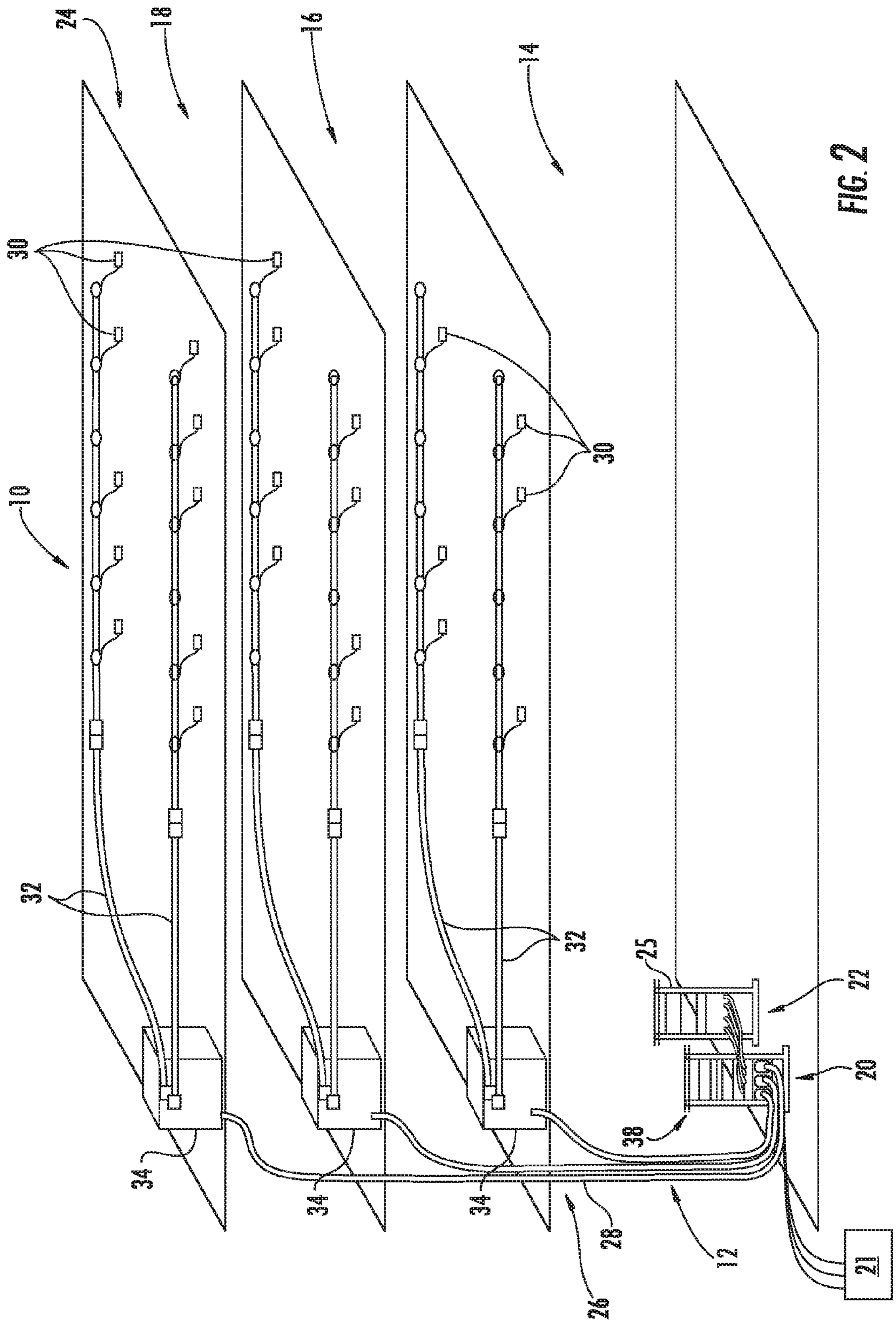

FIG. 2

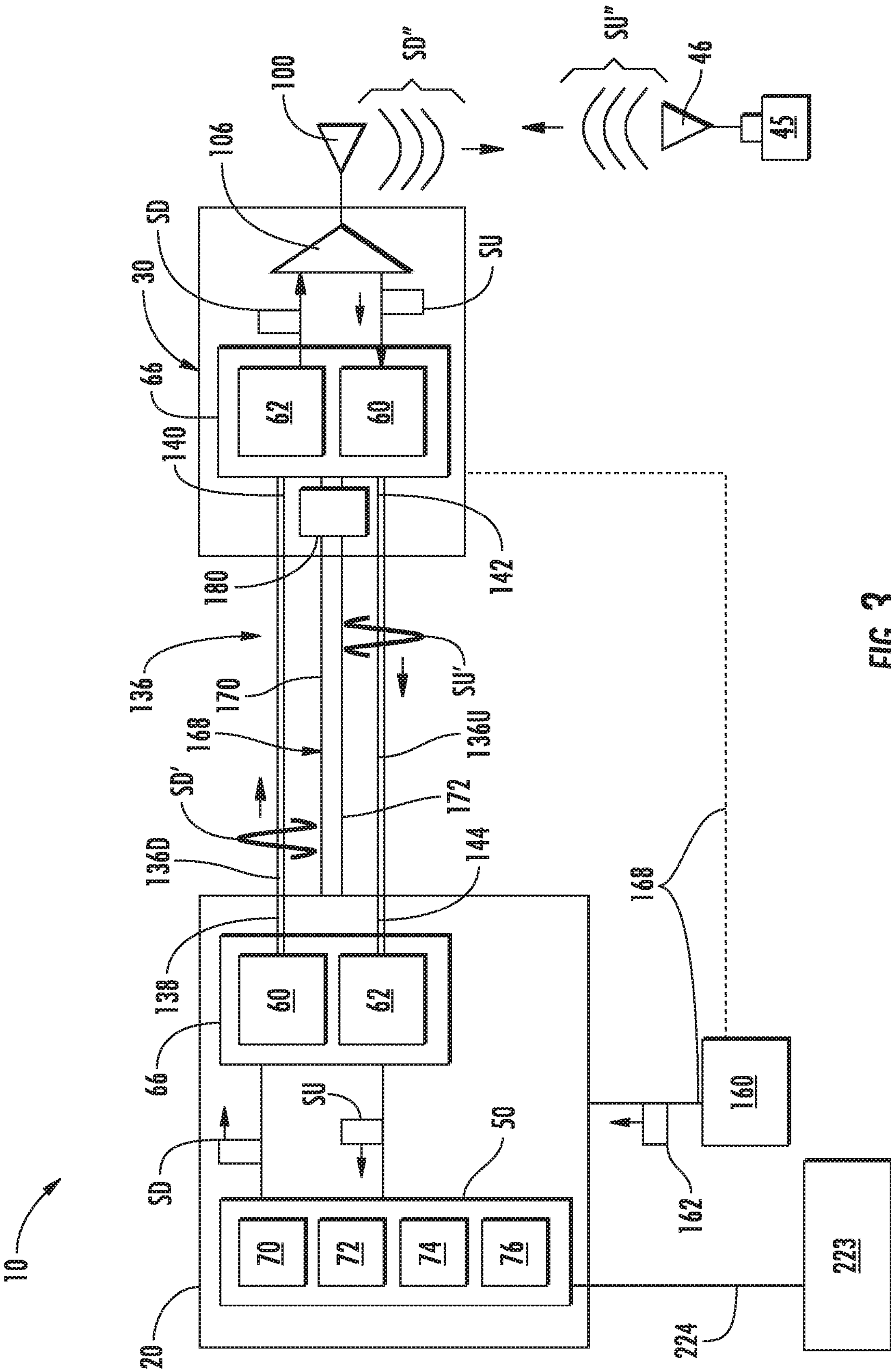
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FIG. 3

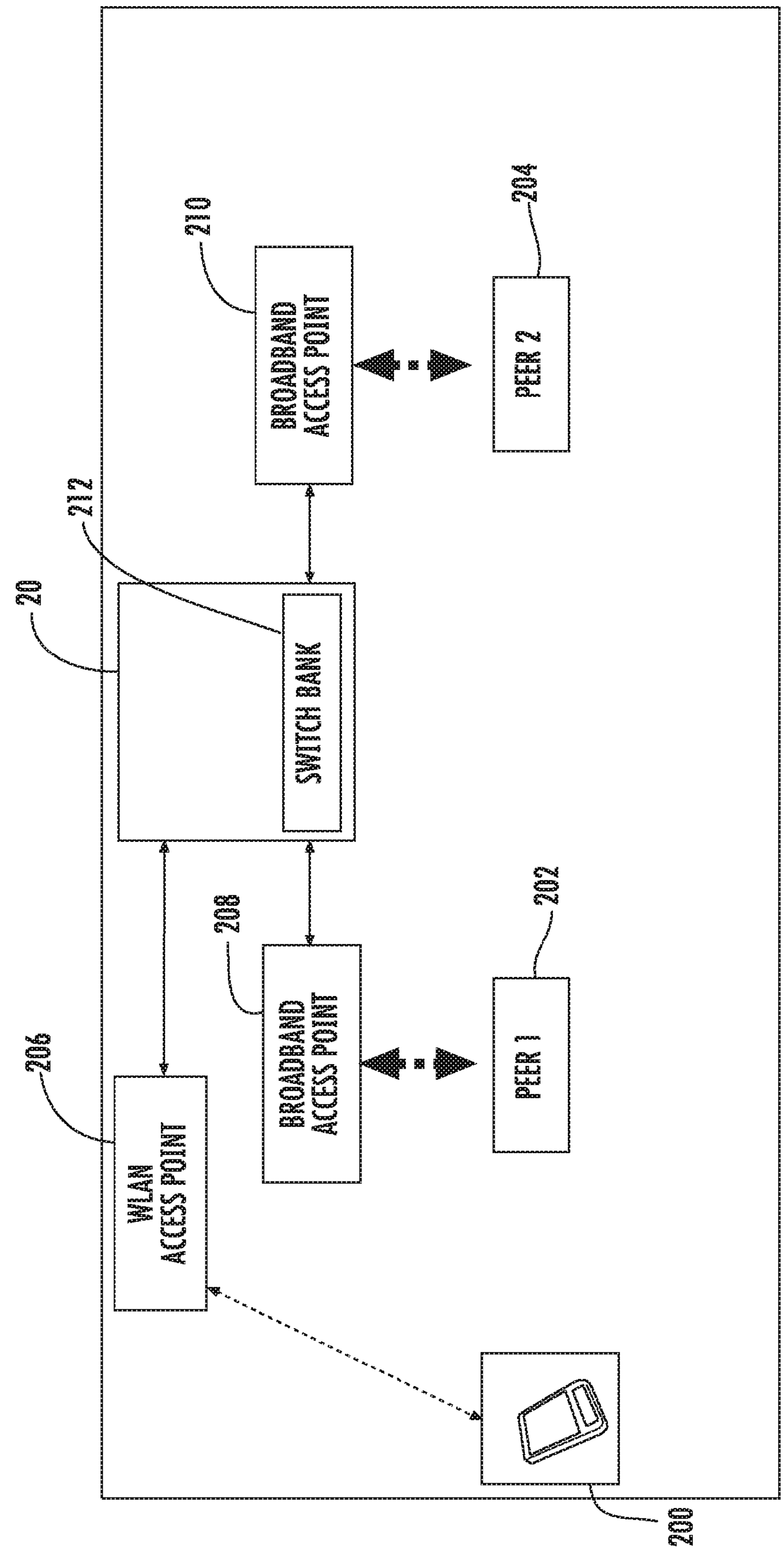
20
212
SWITCH BANK
210
BROADBAND ACCESS POINT
204
PEER 2
206
WLAN ACCESS POINT
208
BROADBAND ACCESS POINT
202
PEER 1
200

FIG. 4

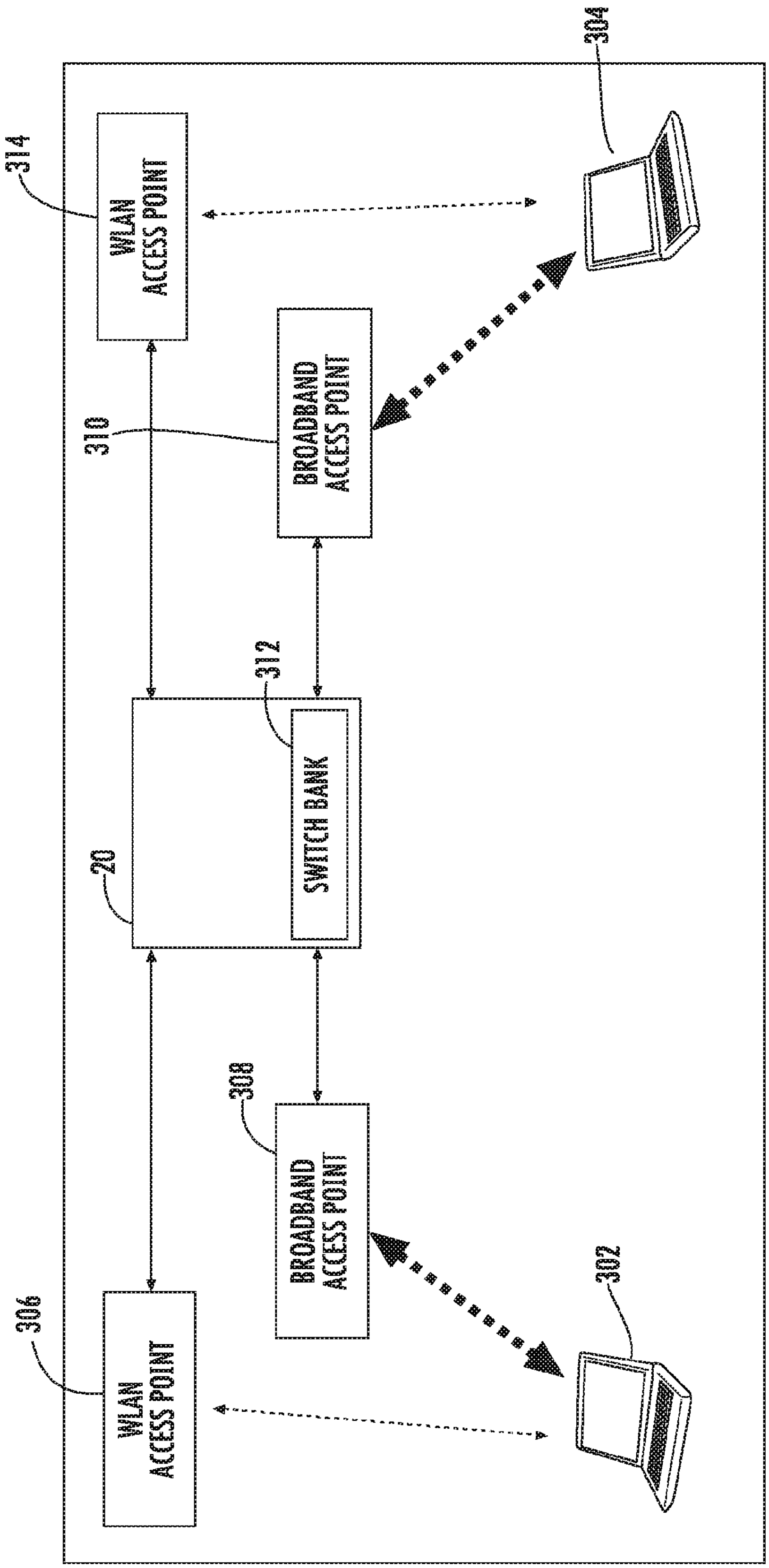
314
WLAN ACCESS POINT
304
310
BROADBAND ACCESS POINT
312
20
SWITCH BANK
308
BROADBAND ACCESS POINT
306
WLAN ACCESS POINT
302

FIG. 5

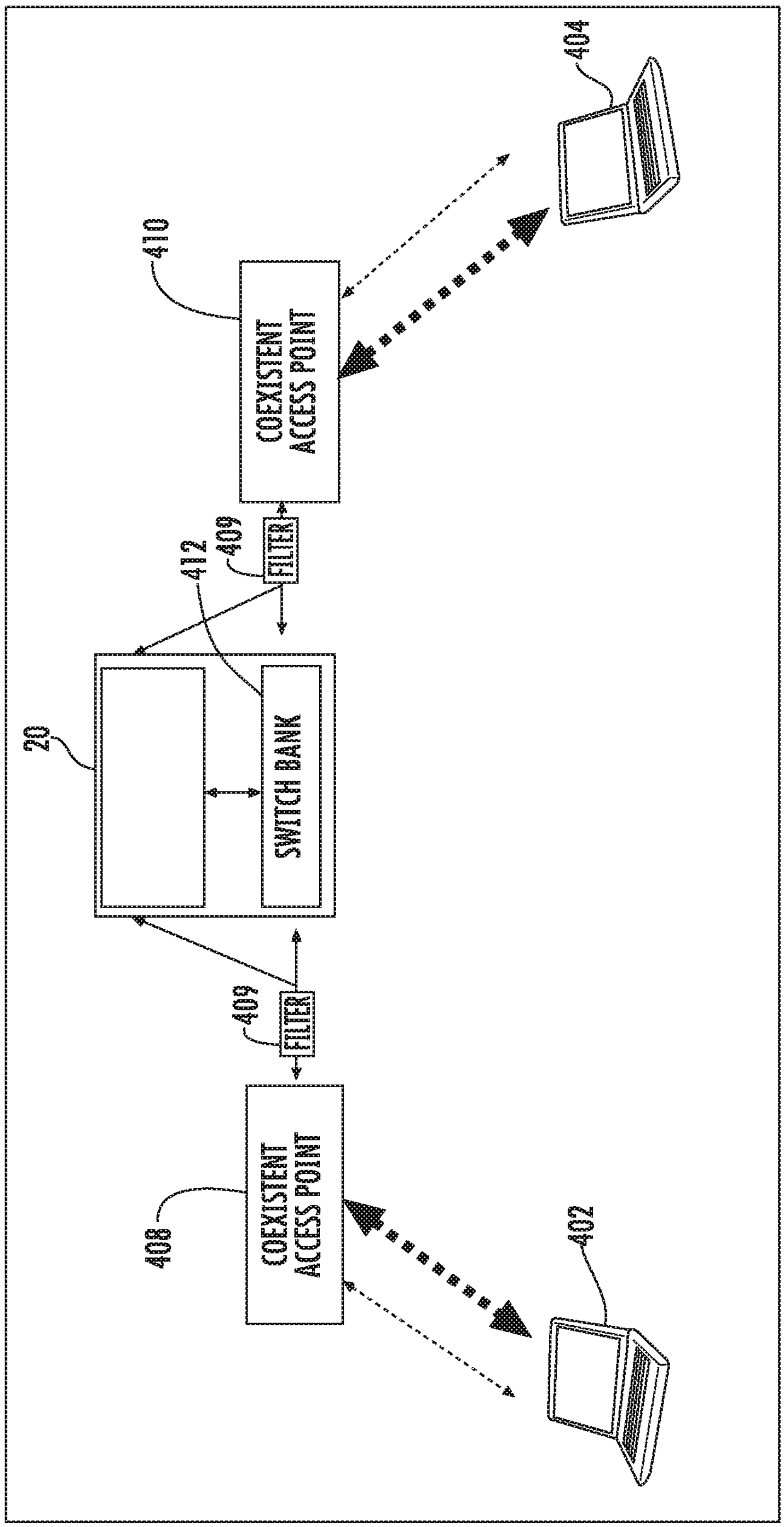
404
410
COEXISTENT ACCESS POINT
409
FILTER
412
20
SWITCH BANK
409
FILTER
408
COEXISTENT ACCESS POINT
402

FIG. 6

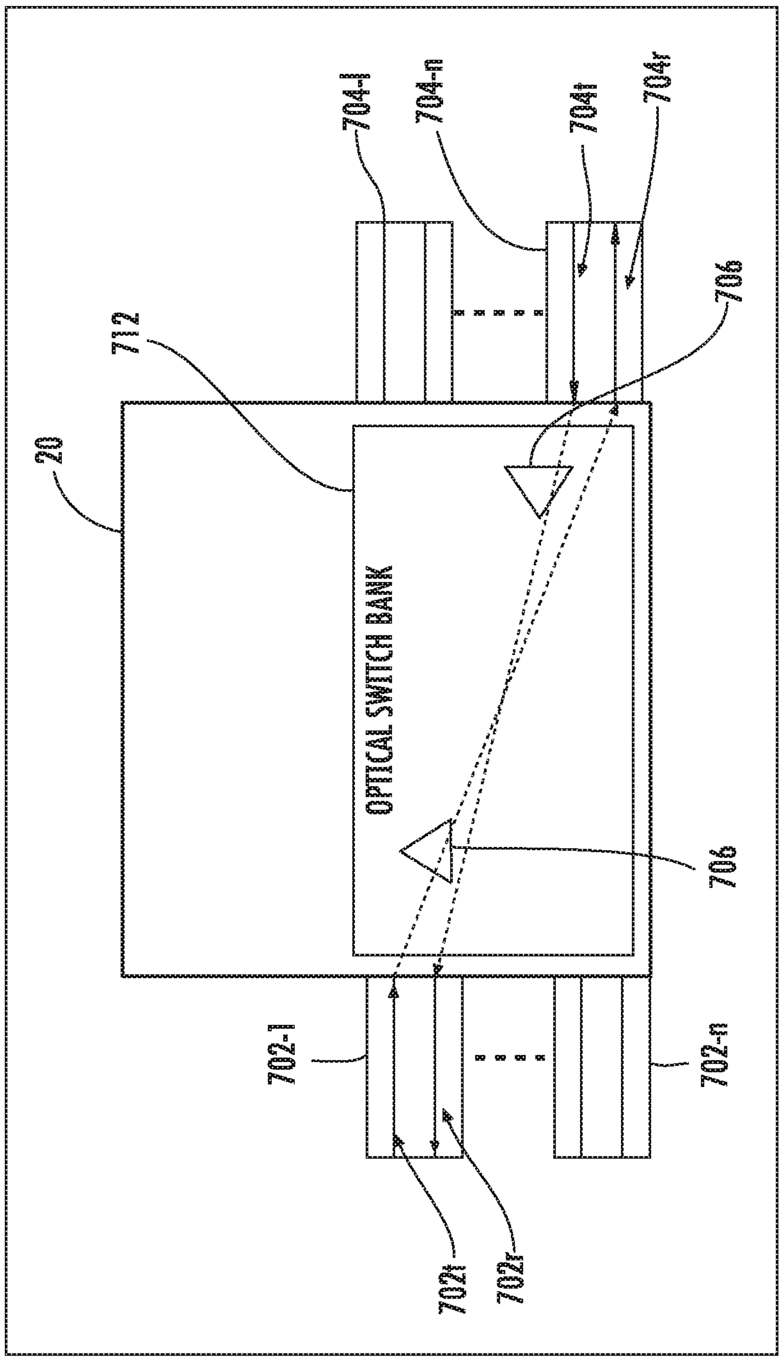
20
712
OPTICAL SWITCH BANK
704-1
704-n
704t
704r
706
706
702-1
702-n
702t
702r

FIG. 7

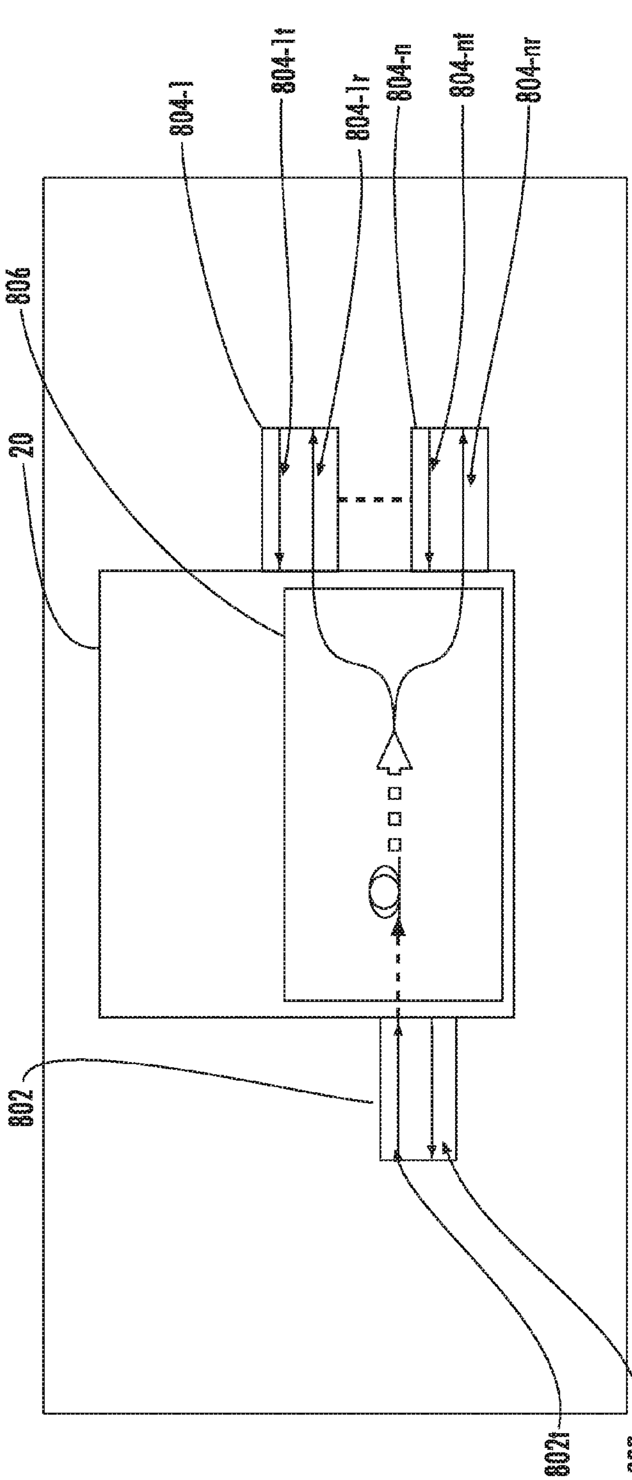
804-1
804-1t
804-1r
804-n
804-nt
804-nr
806
20
802
802t
802r

FIG. 8

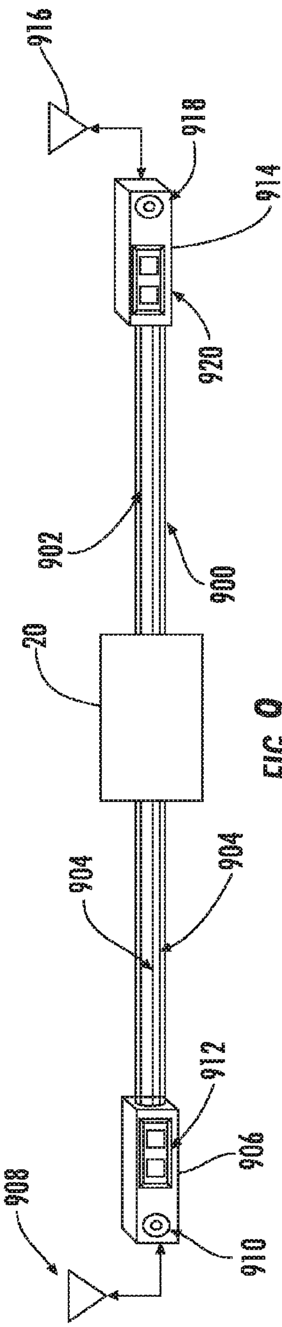
916
918
914
920
902
900
20
904
904
912
906
908
910

FIG. 9

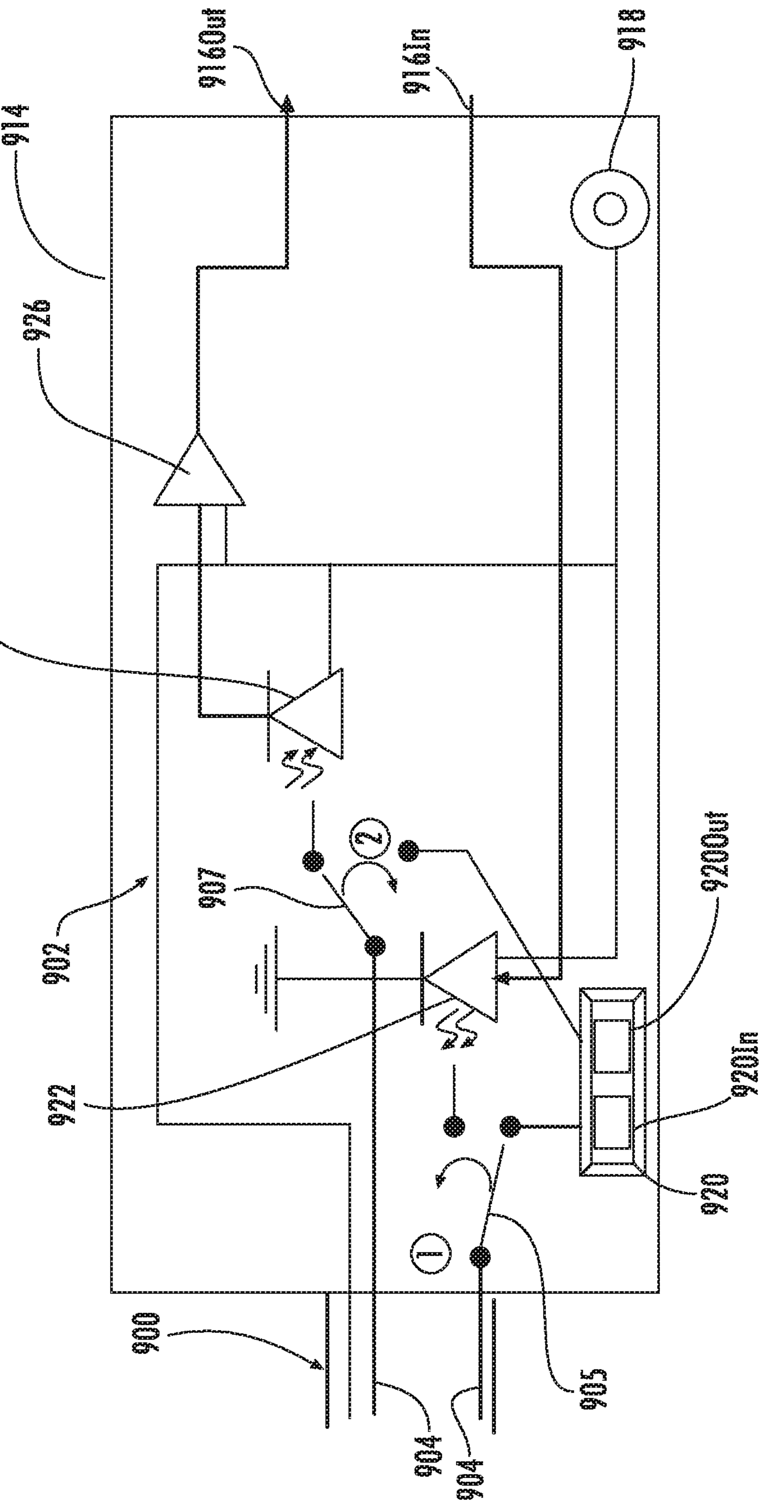
900
902
904
904
905
907
914
916Out
916In
918
920
920In
920Out
922
924
926
1
2

FIG. 10

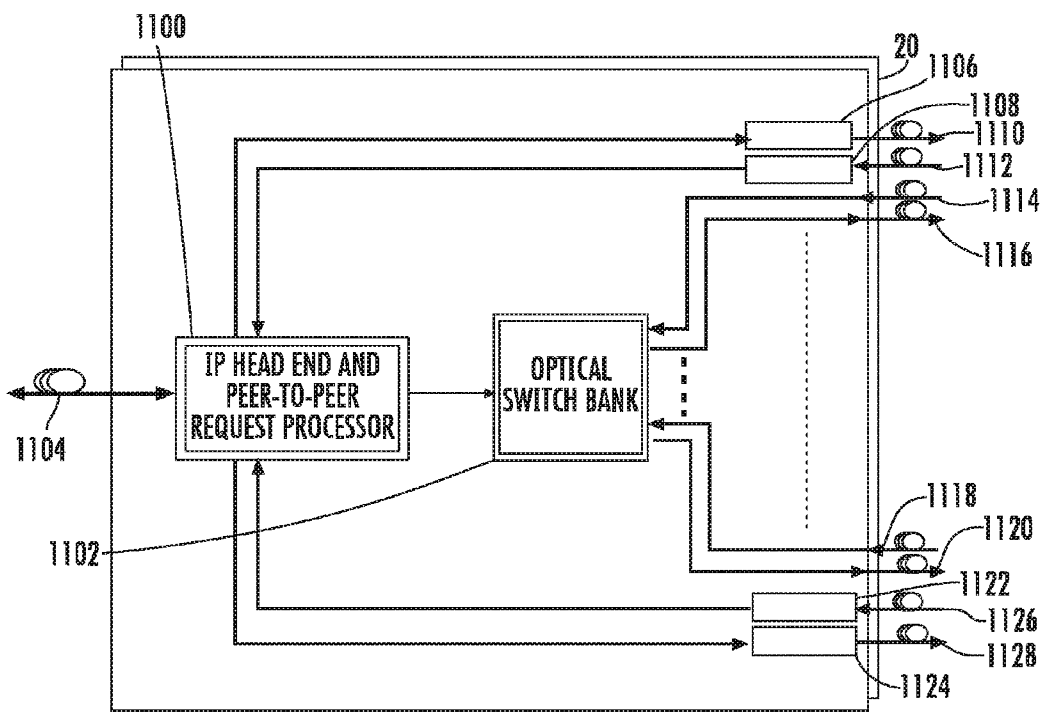
1100
20
1106
1108
1110
1112
1114
1116
IP HEAD END AND PEER-TO-PEER REQUEST PROCESSOR
OPTICAL SWITCH BANK
1104
1102
1118
1120
1122
1126
1128
1124

FIG. 11

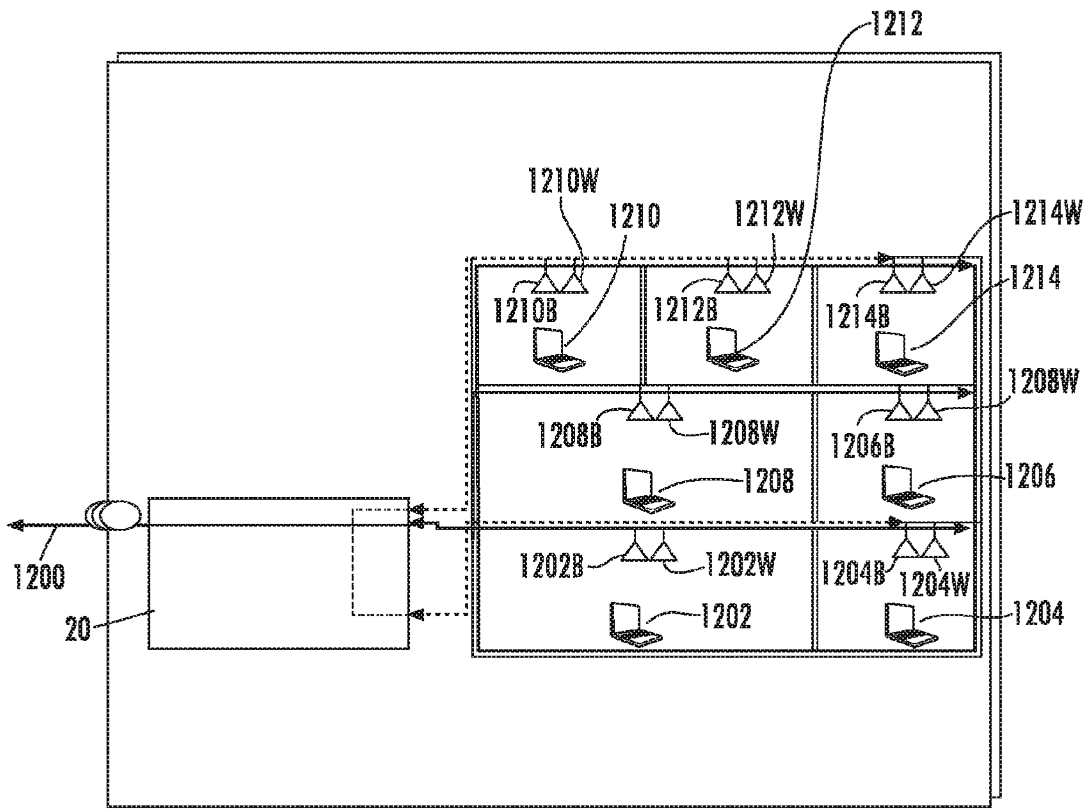
1212
1210W
1210
1212W
1214W
1210B
1212B
1214B
1214
1208W
1208B
1208W
1206B
1206
1208
1200
1202B
1202W
1204B
1204W
20
1202
1204

FIG. 12

RADIO-OVER-FIBER (ROF) SYSTEM FOR PROTOCOL-INDEPENDENT WIRED AND/OR WIRELESS COMMUNICATION

PRIORITY

This application is a continuation of U.S. application Ser. No. 14/146,949, filed Jan. 3, 2014, which is a continuation of U.S. application Ser. No. 13/595,099, filed on Aug. 27, 2012, now U.S. Pat. No. 8,639,121, which is a continuation of U.S. application Ser. No. 12/618,613, filed on Nov. 13, 2009, now U.S. Pat. No. 8,280,259, the contents of which are relied upon and incorporated herein by reference in their entireties, and the benefit of priority under 35 U.S.C. §120 is hereby claimed.

BACKGROUND

1. Field of the Disclosure

The technology of the disclosure relates to wired and/or wireless communication systems employing a wireless communication system.

2. Technical Background

Wireless communication is rapidly growing, with ever-increasing demands for high-speed mobile data communication. As an example, so-called "wireless fidelity" or "WiFi" systems and wireless local area networks (WLANs) are being deployed in many different types of areas (e.g., coffee shops, airports, libraries, etc.). Wireless communication systems communicate with wireless devices called "clients," which must reside within the wireless range or "cell coverage area" in order to communicate with an access point device.

One approach to deploying a wireless communication system involves the use of "picocells." Picocells are radio-frequency (RF) coverage areas. Picocells can have a radius in the range from a few meters up to twenty meters as an example. Combining a number of access point devices creates an array of picocells that cover an area called a "picocellular coverage area." Because the picocell covers a small area, there are typically only a few users (clients) per picocell. This allows for simultaneous high coverage quality and high data rates for the wireless system users, while minimizing the amount of RF bandwidth shared among the wireless system users. One advantage of picocells is the ability to wirelessly communicate with remotely located communication devices within the picocellular coverage area.

One type of wireless communication system for creating picocells is called a "Radio-over-Fiber (RoF)" wireless system. A RoF wireless system utilizes RF signals sent over optical fibers. Such systems include a head-end station optically coupled to a plurality of remote units. The remote units each include transponders that are coupled to the head-end station via an optical fiber link. The transponders in the remote units are transparent to the RF signals. The remote units simply convert incoming optical signals from the optical fiber link to electrical signals via optical-to-electrical (O/E) converters, which are then passed to the transponders. The transponders convert the electrical signals to electromagnetic signals via antennas coupled to the transponders in the remote units. The antennas also receive electromagnetic signals (i.e., electromagnetic radiation) from clients in the cell coverage area and convert the electromagnetic signals to electrical signals (i.e., electrical signals in wire). The remote units then convert the electrical signals to optical signals via electrical-to-optical (E/O) converters. The optical signals are then sent to the head-end station via the optical fiber link.

Wired and wireless peer-to-peer analog and digital communications are generally limited in range and coverage, respectively. Enhancing the range of wired peer-to-peer connections may require complicated amplifying and/or repeating requirements. Extending the coverage of wireless peer-to-peer connections typically requires a denser antenna deployment and/or transmitted power increase, which may be limited by government regulations, wireless standards, and battery peak power and energy storage considerations. In addition, extending the coverage may be prohibited by the use of proprietary protocols, such as medical equipment.

SUMMARY OF THE DETAILED DESCRIPTION

Embodiments disclosed in the detailed description include optically-switched fiber optic wired and/or wireless communication systems and related methods to increase the range of wired and/or wireless peer-to-peer communication systems. The systems can be used to enable, for example, videoconferencing between peer devices. In one embodiment, the optically-switched fiber optic wired and/or wireless communication system may include a head-end unit (HEU) having an optical switch bank. A plurality of fiber optic cables, each of the plurality of fiber optic cables comprising at least one optical fiber, are configured to carry a Radio-over-Fiber (RoF) signal from the HEU to a plurality of remote access points. A first one of the plurality of remote access points is configured to form a corresponding first cellular coverage area where a first peer device is located. A second one of the plurality of remote access points is configured to form a corresponding second, different cellular coverage area where a second peer device is located. The optical switch bank is configured to dynamically establish a RoF-based optical link over at least one of the plurality of fiber optic cables such that the first peer device communicates with the second peer device at least in part over the RoF-based optical link.

Another embodiment disclosed herein provides a method of enabling communication between a first peer device in a first cellular coverage area and a second peer device in a second, different cellular coverage area. The method may include optically linking a plurality of remote access points to a HEU via a plurality of fiber optic cables, each of the plurality of fiber optic cables comprising at least one optical fiber and configured to carry a RoF signal from the HEU to the plurality of remote access points. A first one of the plurality of remote access points is configured to form the first cellular coverage area. A second one of the plurality of remote access points is configured to form the second, different cellular coverage area. A request is received to establish communications between the first peer device and the second peer device, and in response to the request, dynamic establishment of a link is performed over at least one of the plurality of fiber optic cables to allow the first peer device to communicate with the second peer device at least in part over the link.

The systems and methods disclosed herein can be configured to overcome the limitations of traditional wired and/or wireless ("wired/wireless") peer-to-peer communications by combining the low loss, high bandwidth nature of optical fiber with an appropriate optical switching network to enhance coverage (where needed). In one embodiment, the switched fiber optic wired/wireless communication system is a link system. In another embodiment, the link system is nearly protocol transparent (i.e., independent of protocol).

The switched wired/wireless communication systems and methods disclosed herein may include dense fiber cable deployment (as in picocell), which facilitates cell-to-cell peer-to-peer communication. By taking advantage of the fiber cable architecture of the switched fiber optic wired/wireless communication system, such as a Wireless Local Area Network (WLAN) picocell system, the peer-to-peer communication range is extended to be cell-to-cell. In this regard, devices in any two cells can communicate in the peer-to-peer mode independent of their physical distance, such that the peer-to-peer range extends across entire indoor installation areas.

In addition, the switched fiber optic wired/wireless communication systems and methods disclosed herein can use optical cable links that are nearly transparent to wireless protocols, thereby eliminating proprietary protocol compliance requirements. Thus, a broad variety of current applications/equipment are supported without any infrastructure upgrade, including switched video connection, switched video with Internet connection, peer-to-peer proprietary protocol equipment (e.g. medical), peer-to-peer videoconferencing, and broadcast capability (cellular and video). In addition, future applications/equipment will be possible without any infrastructure upgrade.

The switched wired/wireless communication system and method disclosed herein take advantage of a local wireless network, such as a WLAN, to initiate peer-to-peer switching, because the switching only needs a very low data rate connection. Multiple input options may be supported, such as a radio frequency (RF) cable/antenna input, an optical fiber input, and an electrical power input. Multiple output options can be used, including an RF cable/antenna output, an optical fiber output with optical/electrical conversion, an optical fiber output with the E/O conversion bypassed, and an electrical power output. The switched wired/wireless communication system disclosed herein can be upgraded to higher frequencies, such as 60 Gigahertz (GHz).

Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a schematic diagram of an exemplary generalized embodiment of an optical fiber-based wireless picocellular system;

FIG. **2** is a schematic diagram of an exemplary Radio-over-Fiber (RoF) distributed communication system;

FIG. **3** is a more detailed schematic diagram of an exemplary embodiment of the system of FIG. **1**, showing the head-end unit (HEU) and one remote unit and picocell of the exemplary system of FIG. **1**;

FIG. **4** is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired and/or wireless ("wired/wireless") communication system to allow proprietary protocol data transfer between peer-to-peer devices according to an exemplary embodiment;

FIG. **5** is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system to allow videoconferencing between peer-to-peer devices according to an exemplary embodiment;

FIG. **6** is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system to allow communication between peer-to-peer devices through co-existent access points according to an exemplary embodiment;

FIG. **7** is a schematic diagram of an exemplary embodiment of an optical switching bank at a HEU of an optically-switched fiber optic wired/wireless communication system;

FIG. **8** is a schematic diagram of an exemplary embodiment of using optical amplification and splitting at a HEU of an optically-switched fiber optic wired/wireless communication system for broadcasting video to peer-to-peer devices;

FIG. **9** is a schematic diagram of an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system that illustrates an exemplary connection between a HEU and broadband transponders in two different locations;

FIG. **10** is a schematic diagram of an exemplary embodiment of a broadband transponder that may be used in an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system;

FIG. **11** is a schematic diagram of an exemplary embodiment of a HEU of an optically-switched fiber optic wired/wireless communication system; and

FIG. **12** is a schematic diagram of an exemplary embodiment of a Radio-over-Fiber based wireless communication system.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

Embodiments disclosed in the detailed description include optically-switched fiber optic wired and/or wireless communication systems and related methods to increase the range of wired and/or wireless peer-to-peer communication systems. In one embodiment, the optically-switched fiber optic wired and/or wireless communication system may include a head-end unit (HEU) having an optical switch bank. A plurality of fiber optic cables, each of the plurality of fiber optic cables comprising at least one optical fiber, are configured to carry a Radio-over-Fiber (RoF) signal from the HEU to a plurality of remote access points. A first one of the plurality of remote access points is configured to form a corresponding first cellular coverage area where a first peer device is located. A second one of the plurality of remote access points is configured to form a corresponding second, different cellular coverage area where a second peer device is located. The optical switch bank is configured to dynamically establish a RoF-based optical link over at least one of the plurality of fiber optic cables such that the first peer device communicates with the second peer device at least in part over the RoF-based optical link. These systems and methods can overcome the limitations of traditional wired/wireless peer-to-peer communications by combining the low loss, high bandwidth nature of optical fiber with an appropriate optical switching network to enhance coverage (where needed). In one embodiment, the optically-switched fiber optic wired/wireless communication system is a RoF-based link system. In another embodiment, the RoF-based link system is nearly protocol transparent (i.e., independent of protocol).

Before discussing specifics regarding exemplary embodiments of optically-switched fiber optic wired/wireless communication systems disclosed herein starting with FIG. **4**, FIGS. **1-3** are first set forth and discussed to describe a generalized embodiment of an optical-fiber-based wireless picocellular system. In this regard, FIG. **1** is a schematic diagram of a generalized embodiment of an optical-fiber-based wireless picocellular system **10** (also referred to herein as "system **10**"). The system **10** includes a head-end unit (HEU) **20**, one or more transponder or remote antenna units **30**, or simply referred to herein as "remote units **30**", and an optical fiber radio frequency (RF) communication link **36** that optically couples the HEU **20** to the remote unit **30**. As discussed in detail below, the system **10** has a picocell **40** substantially centered about the remote unit **30**. The remote units **30** form a picocellular coverage area **44**. The HEU **20** is adapted to perform or to facilitate any one of a number of RF-over-fiber applications, such as radio frequency identification (RFID), wireless local area network (WLAN) communication, Bluetooth®, or cellular phone service. Shown within the picocell **40** is a device **45**. The device **45** may be a hand-held communication device (e.g., a cellular telephone or personal digital assistant (PDA)), a personal computer, a video monitor, or any other device that is capable of communicating with a peer device. The device **45** may have an antenna **46** associated with it.

Although the embodiments described herein include any type of optically-switched fiber optic wired/wireless communication system, including any type of RoF system, an exemplary RoF distributed communication system **11** is provided in FIG. **2** to facilitate discussion of the environment in which the peer-to-peer communication between two devices in different cells is enabled. FIG. **2** includes a partially schematic cut-away diagram of a building infrastructure **12** that generally represents any type of building in which the RoF distributed communication system **11** might be employed and used. The building infrastructure **12** includes a first (ground) floor **14**, a second floor **16**, and a third floor **18**. The floors **14**, **16**, **18** are serviced by the HEU **20**, through a main distribution frame **22**, to provide a coverage area **24** in the building infrastructure **12**. Only the ceilings of the floors **14**, **16**, **18** are shown in FIG. **2** for simplicity of illustration.

In an example embodiment, the HEU **20** is located within the building infrastructure **12**, while in another example embodiment, the HEU **20** may be located outside of the building infrastructure **12** at a remote location. A base transceiver station (BTS) **25**, which may be provided by a second party such as a cellular service provider, is connected to the HEU **20**, and can be co-located or located remotely from the HEU **20**. In a typical cellular system, for example, a plurality of base transceiver stations are deployed at a plurality of remote locations to provide wireless telephone coverage. Each BTS serves a corresponding cell and when a mobile station enters the cell, the BTS communicates with the mobile station. Each BTS can include at least one radio transceiver for enabling communication with one or more subscriber units operating within the associated cell.

A main cable **26** enables multiple fiber optic cables **32** to be distributed throughout the building infrastructure **12** to remote units **30** to provide the coverage area **24** for the first, second and third floors **14**, **16**, and **18**. Each remote unit **30** in turn services its own coverage area in the coverage area **24**. The main cable **26** can include a riser cable **28** that carries all of the uplink and downlink fiber optic cables **32** to and from the HEU **20**. The main cable **26** can also include one or more multi-cable (MC) connectors adapted to connect select downlink and uplink optical fiber cables to a number of fiber optic cables **32**. In this embodiment, an interconnect unit (ICU) **34** is provided for each floor **14**, **16**, **18**, the ICUs **34** including a passive fiber interconnection of optical fiber cable ports. The fiber optic cables **32** can include matching connectors. In an example embodiment, the riser cable **28** includes a total of thirty-six (36) downlink and thirty-six (36) uplink optical fibers, while each of the six (6) fiber optic cables **32** carries six (6) downlink and six (6) uplink optical fibers to service six (6) remote units **30**. Each fiber optic cable **32** is in turn connected to a plurality of remote units **30** each having an antenna that provides the overall coverage area **24**.

In this example embodiment, the HEUs **20** provide electrical radio-frequency (RF) service signals by passing (or conditioning and then passing) such signals from one or more outside networks **21** to the coverage area **24**. The HEUs **20** are electrically coupled to an electrical-to-optical (E/O) converter **38** within the HEU **20** that receives electrical RF service signals from the one or more outside networks **21** and converts them to corresponding optical signals. The optical signals are transported over the riser cables **28** to the ICUs **34**. The ICUs **34** include passive fiber interconnection of optical fiber cable ports that pass the optical signals over the fiber optic cables **32** to the remote units **30** to provide the coverage area **24**. In an example embodiment, the E/O converter **38** includes a laser suitable for delivering sufficient dynamic range for the RoF applications, and optionally includes a laser driver/amplifier electrically coupled to the laser. Examples of suitable lasers for the E/O converter **38** include laser diodes, distributed feedback (DFB) lasers, Fabry-Perot (FP) lasers, and vertical cavity surface emitting lasers (VCSELs).

The HEUs **20** are adapted to perform or to facilitate any one of a number of RoF applications, including but not limited to radio-frequency identification devices (RFIDs), wireless local area network (WLAN) communications, Bluetooth®, and/or cellular phone services. In a particular example embodiment, this includes providing WLAN signal distribution as specified in the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard, i.e., in the frequency range from 2.4 to 2.5 GigaHertz (GHz) and from 5.0 to 6.0 GHz. In another example embodiment, the HEUs **20** provide electrical RF service signals by generating the signals directly. In yet another example embodiment, the HEUs **20** coordinate the delivery of the electrical RF service signals between client devices within the coverage area **24**.

The number of optical fibers and fiber optic cables **32** can be varied to accommodate different applications, including the addition of second, third, or more HEUs **20**. In this example, the RoF distributed communication system **11** incorporates multiple HEUs **20** to provide various types of wireless service to the coverage area **24**. The HEUs **20** can be configured in a master/slave arrangement where one HEU **20** is the master and the other HEU **20** is a slave. Also, one or more than two HEUs **20** may be provided depending on desired configurations and the number of coverage area **24** cells desired.

FIG. **3** is a schematic diagram of an exemplary embodiment of the optical fiber-based wireless picocellular system **10** of FIG. **1**. In this exemplary embodiment, the HEU **20** includes a service unit **50** that provides electrical RF service signals for a particular wireless service or application. The service unit **50** provides electrical RF service signals by passing (or conditioning and then passing) such signals from one or more outside networks **223**, as described below. In a particular embodiment, this may include providing ultra wide band-impulse response (UWB-IR) signal distribution in the range of 3.1 to 10.6 GHz. Other signal distribution is also possible, including WLAN signal distribution as specified in the IEEE 802.11 standard, i.e., in the frequency range from 2.4 to 2.5 GHz and from 5.0 to 6.0 GHz. In another embodiment, the service unit **50** may provide electrical RF service signals by generating the signals directly.

The service unit **50** is electrically coupled to an E/O converter **60** that receives an electrical RF service signal from the service unit **50** and converts it to corresponding optical signal, as discussed in further detail below. In an exemplary embodiment, the E/O converter **60** includes a laser suitable for delivering sufficient dynamic range for the RF-over-fiber applications, and optionally includes a laser driver/amplifier electrically coupled to the laser. Examples of suitable lasers for the E/O converter **60** include laser diodes, distributed feedback (DFB) lasers, Fabry-Perot (FP) lasers, and vertical cavity surface emitting lasers (VCSELs).

The HEU **20** also includes an O/E converter **62** electrically coupled to the service unit **50**. The O/E converter **62** receives an optical RF service signal and converts it to a corresponding electrical signal. In one embodiment, the O/E converter **62** is a photodetector, or a photodetector electrically coupled to a linear amplifier. The E/O converter **60** and the O/E converter **62** constitute a “converter pair” **66**.

In an exemplary embodiment, the service unit **50** includes an RF signal modulator/demodulator unit **70** that generates an RF carrier of a given frequency and then modulates RF signals onto the carrier. The modulator/demodulator unit **70** also demodulates received RF signals. The service unit **50** also includes a digital signal processing unit (“digital signal processor”) **72**, a central processing unit (CPU) **74** for processing data and otherwise performing logic and computing operations, and a memory unit **76** for storing data, such as system settings, status information, RFID tag information, etc. In an exemplary embodiment, the different frequencies associated with the different signal channels are created by the modulator/demodulator unit **70** generating different RF carrier frequencies based on instructions from the CPU **74**. Also, as described below, the common frequencies associated with a particular combined picocell are created by the modulator/demodulator unit **70** generating the same RF carrier frequency.

With continuing reference to FIG. **3**, in one embodiment, a remote unit **30** includes a converter pair **66**, wherein the E/O converter **60** and the O/E converter **62** therein are electrically coupled to an antenna system **100** via an RF signal-directing element **106**, such as a circulator. The RF signal-directing element **106** serves to direct the downlink and uplink electrical RF service signals, as discussed below. In an exemplary embodiment, the antenna system **100** includes a broadband (3.1 to 10.6 GHz) antenna integrated into a fiber optic array cable.

The remote units **30** may be a typical access point device, or part of a typical access point device. In one embodiment, the remote units **30** may be typical WLAN access points. In another embodiment, the remote units **30** may be typical broadband access points, or ultra-wide broadband (UWB) access points. In yet another embodiment, the remote units **30** may be co-existent (both WLAN and broadband-UWB) access points. The remote units **30** may be any device capable of forming a picocell or other cellular coverage area substantially centered about the remote unit **30** in which devices within the picocell or other cellular coverage area can communicate with the remote unit **30**. In a further embodiment, the remote units **30** differ from the typical access point device associated with wireless communication systems in that the preferred embodiment of the remote unit **30** has just a few signal-conditioning elements and no digital information processing capability. Rather, the information processing capability is located remotely in the HEU **20**, and in a particular example, in the service unit **50**. This allows the remote unit **30** to be very compact and virtually maintenance free. In addition, the preferred exemplary embodiment of the remote unit **30** consumes very little power, is transparent to RF signals, and does not require a local power source.

With reference again to FIG. **3**, an exemplary embodiment of the optical fiber RF communication link **136** includes a downlink optical fiber **136**D having a downlink optical fiber input end **138** and a downlink optical fiber output end **140**, and an uplink optical fiber **136**U having an uplink optical fiber input end **142** and an uplink optical fiber output end **144**. The downlink and uplink optical fibers **136**D and **136**U optically couple the converter pair **66** at the HEU **20** to the converter pair **66** at the remote unit **30**. Specifically, the downlink optical fiber input end **138** is optically coupled to the E/O converter **60** of the HEU **20**, while the downlink optical fiber output end **140** is optically coupled to the O/E converter **62** at the remote unit **30**. Similarly, the uplink optical fiber input end **142** is optically coupled to the E/O converter **60** of the remote unit **30**, while the uplink optical fiber output end **144** is optically coupled to the O/E converter **62** at the HEU **20**.

In one embodiment, the system **10** employs a known telecommunications wavelength, such as 850 nanometers (nm), 1300 nm, or 1550 nm. In another exemplary embodiment, the system **10** employs other less common but suitable wavelengths such as 980 nm.

Exemplary embodiments of the system **10** include either single-mode optical fiber or multi-mode optical fiber for the downlink and uplink optical fibers **136**D and **136**U. The particular type of optical fiber depends on the application of the system **10**. For many in-building deployment applications, maximum transmission distances typically do not exceed 300 meters. The maximum length for the intended RF-over-fiber transmission needs to be taken into account when considering using multi-mode optical fibers for the downlink and uplink optical fibers **136**D and **136**U. For example, it has been shown that a 1400 MHz/km multi-mode fiber bandwidth-distance product is sufficient for 5.2 GHz transmission up to 300 m.

In one embodiment, a 50 micrometers (μm) multi-mode optical fiber is used for the downlink and uplink optical fibers **136**D and **136**U, and the E/O converters **60** operate at 850 nm using commercially available VCSELs specified for 10 Gigabits per second (Gb/s) data transmission. In a more specific exemplary embodiment, OM3 50 μm multi-mode optical fiber is used for the downlink and uplink optical fibers **136**D and **136**U.

The system **10** also includes a power supply **160** that generates an electrical power signal **162**. The power supply

160 is electrically coupled to the HEU 20 for powering the power-consuming elements therein. In one embodiment, an electrical power line 168 runs through the HEU 20 and over to the remote unit 30 to power the E/O converter 60 and the O/E converter 62 in the converter pair 66, the optional RF signal-directing element 106 (unless the optional RF signal-directing element 106 is a passive device such as a circulator), and any other power-consuming elements (not shown). In an exemplary embodiment, the electrical power line 168 includes two wires 170 and 172 that carry a single voltage and that are electrically coupled to a DC power converter 180 at the remote unit 30. The DC power converter 180 is electrically coupled to the E/O converter 60 and the O/E converter 62 in the remote unit 30, and changes the voltage or levels of the electrical power signal 162 to the power level(s) required by the power-consuming components in the remote unit 30. In one embodiment, the DC power converter 180 is either a DC/DC power converter or an AC/DC power converter, depending on the type of electrical power signal 162 carried by the electrical power line 168. In an exemplary embodiment, the electrical power line 168 includes standard electrical-power-carrying electrical wire(s), e.g., 18-26 AWG (American Wire Gauge) used in standard telecommunications and other applications. In another exemplary embodiment, the electrical power line 168 (shown as a dashed line in FIG. 3) runs directly from the power supply 160 to the remote unit 30 rather than from or through the HEU 20. In another exemplary embodiment, the electrical power line 168 includes more than two wires and carries multiple voltages.

In another embodiment, the HEU 20 is operably coupled to the outside networks 223 via a network link 224.

With reference to the optical-fiber-based wireless picocellular system 10 of FIGS. 1 and 3, the service unit 50 generates an electrical downlink RF service signal SD ("electrical signal SD") corresponding to its particular application. In one embodiment, this is accomplished by the digital signal processor 72 providing the modulator/demodulator unit 70 with an electrical signal (not shown) that is modulated onto an RF carrier to generate a desired electrical signal SD. The electrical signal SD is received by the E/O converter 60, which converts this electrical signal SD into a corresponding optical downlink RF signal SD' ("optical signal SD'"), which is then coupled into the downlink optical fiber 136D at the input end 138. It is noted here that in one embodiment, the optical signal SD' is tailored to have a given modulation index. Further, in an exemplary embodiment, the modulation power of the E/O converter 60 is controlled (e.g., by one or more gain-control amplifiers, not shown) to vary the transmission power from the antenna system 100. In an exemplary embodiment, the amount of power provided to the antenna system 100 is varied to define the size of the associated picocell 40, which in exemplary embodiments range anywhere from about a meter across to about twenty meters across.

The optical signal SD' travels over the downlink optical fiber 136D to the output end 140, where it is received by the O/E converter 62 in the remote unit 30. The O/E converter 62 converts the optical signal SD' back into an electrical signal SD, which then travels to the RF signal-directing element 106. The RF signal-directing element 106 then directs the electrical signal SD to the antenna system 100. The electrical signal SD is fed to the antenna system 100, causing it to radiate a corresponding electromagnetic downlink RF signal SD" ("electromagnetic signal SD").

When the device 45 is located within the picocell 40, the electromagnetic signal SD" is received by the antenna 46. The antenna 46 converts the electromagnetic signal SD" into an electrical signal SD in the device 45, and processes the electrical signal SD. The device 45 can generate electrical uplink RF signals SU, which are converted into electromagnetic uplink RF signals SU" ("electromagnetic signal SU"") by the antenna 46.

When the device 45 is located within the picocell 40, the electromagnetic signal SU" is detected by the antenna system 100 in the remote unit 30, which converts the electromagnetic signal SU" back into an electrical signal SU. The electrical signal SU is directed by the RF signal-directing element 106 to the E/O converter 60 in the remote unit 30, which converts this electrical signal into a corresponding optical uplink RF signal SU' ("optical signal SU'"), which is then coupled into the input end 142 of the uplink optical fiber 136U. The optical signal SU' travels over the uplink optical fiber 136U to the output end 144, where it is received by the O/E converter 62 at the HEU 20. The O/E converter 62 converts the optical signal SU' back into an electrical signal SU, which is then directed to the service unit 50. The service unit 50 receives and processes the electrical signal SU, which in one embodiment includes one or more of the following: storing the signal information; digitally processing or conditioning the signals; sending the signals on to one or more outside networks 223 via network links 224; and sending the signals to one or more devices 45 in the picocellular coverage area 44. In an exemplary embodiment, the processing of the electrical signal SU includes demodulating the electrical signal SU in the modulator/demodulator unit 70, and then processing the demodulated signal in the digital signal processor 72.

FIGS. 4-6 illustrate three embodiments of protocol-independent RoF wireless presence. All of these embodiments have a WLAN-requesting switching network to initiate a protocol-independent peer-to-peer connection.

FIG. 4 is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system to allow proprietary protocol data transfer between peer-to-peer devices according to an exemplary embodiment. In FIG. 4, a peer device 202 is located in a different cellular coverage area ("cell") than a peer device 204. The peer device 202 is capable of communicating with an access point 208 through a wireless connection (indicated by the dashed line) when the peer device 202 is within a first cell defined by the access point 208. The peer device 204 is capable of communicating with an access point 210 through a wireless connection (indicated by the dashed line) when the peer device 204 is within a second cell defined by the access point 210. The access points 208 and 210 may be broadband access points, or broadband transponders. In one embodiment, the access points 208 and 210 may be similar to the remote units 30 described above with respect to FIG. 3, where the remote units 30 include a converter pair 66, wherein the E/O converter 60 and the O/E converter 62 therein are electrically coupled to an antenna system 100 via an RF signal-directing element 106, such as a circulator.

The access points 208 and 210 are optically coupled to a HEU 20 by optical fibers in a fiber optic cable (as represented by the solid lines between the access points 208 and 210 and the HEU 20). In one embodiment, the optical fibers may connect the access points 208 and 210 to the HEU 20 in a manner similar to that illustrated in FIGS. 2 and/or 3. FIG. 4 illustrates using a device 200 (e.g., PDA or cellular telephone) that is different than the peer device 202 to request the peer-to-peer switching. The device 200 sends a peer-to-peer request to a WLAN access point 206 (as indicated by the dashed line). The WLAN access point **206** is also optically coupled to the HEU **20** by optical fibers in a fiber optic cable (as represented by the solid lines between the WLAN access point **206** and the HEU **20**) such that the peer-to-peer request is sent from the WLAN access point **206** to the HEU **20**.

When the HEU **20** receives the peer-to-peer request, an optical switch bank **212** dynamically selects the appropriate optical fibers to connect the access points **208** and **210** so that the peer devices **202** and **204** associated with the access points **208** and **210** can communicate with each other. Once the optical switch bank **212** dynamically selects the appropriate optical fibers to connect the access points **208** and **210**, the peer device **202** can communicate wirelessly with the access point **208** using whatever protocol the peer device **202** and the access point **208** are capable of using, and the peer device **204** can communicate wirelessly with the access point **210** using whatever protocol the peer device **204** and the access point **210** are capable of using. In this manner, peer-to-peer communication between the peer devices **202** and **204** in different cells using different wireless protocols is enabled through the optical switch bank **212** establishing a dynamic optical link between the access points **208** and **210** of the two different cells.

This scenario could be used in medical applications such as a hospital or other medical facility, where a doctor using a PDA might request that high resolution images (X-ray, MRI, etc.) stored on remote proprietary devices be displayed on a bedside proprietary-protocol-based monitor. For example, the peer device **202** could have be a computer in a hospital records area that has X-ray data stored on it. Through the use of the system shown in FIG. **4**, the data from the peer device **202** could be transmitted to the peer device **204**, which might be a computer terminal or other monitor or display in a patient's room that is on a different floor from the records room where the peer device **202** is located.

FIG. **5** is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system to allow videoconferencing between peer-to-peer devices according to an exemplary embodiment. In FIG. **5**, a peer device **302** is located in a different cell than a peer device **304**. The peer device **302** is capable of communicating with an access point **308** through a wireless connection (indicated by the dashed line) when the peer device **302** is within a first cell defined by the access point **308**. The peer device **304** is capable of communicating with an access point **310** through a wireless connection (indicated by the dashed line) when the peer device **304** is within a second cell defined by the access point **310**. The access points **308** and **310** may be broadband access points, or broadband transponders. In one embodiment, the access points **308** and **310** may be similar to the remote units **30** described above with respect to FIG. **3**, where the remote units **30** include a converter pair **66**, wherein the E/O converter **60** and the O/E converter **62** therein are electrically coupled to an antenna system **100** via an RF signal-directing element **106**, such as a circulator.

The access points **308** and **310** are optically coupled to a HEU **20** by optical fibers in a fiber optic cable (as represented by the solid lines between the access points **308** and **310** and the HEU **20**). In one embodiment, the optical fibers may connect the access points **308** and **310** to the HEU **20** in a manner similar to that illustrated in FIGS. **2** and/or **3**. The exemplary system shown in FIG. **5** works in a similar manner as that shown in FIG. **4**. The scenario illustrated in FIG. **5** differs from that of FIG. **4** in that one of the peer devices **302** or **304** initiates the connection, instead of requiring a different device (e.g., PDA). This is applicable in situations where the peer devices **302** and **304** both have WLAN access and a broadband wireless (possibly proprietary-protocol) network and desire to participate in a videoconference. Thus, in one embodiment, the peer devices **302** and **304** may be computing devices, such as laptop computers, the access points **308** and **310** may be broadband access points, and the access points **306** and **314** may be WLAN access points. For example, the embodiment of FIG. **5** could utilize an existing low data rate WLAN that is insufficient for a video application (e.g., 802.11b) by allowing a laptop computer to place the request for a peer-to-peer connection on the low data rate network, and have the video information transferred via a peer-to-peer broadband higher data rate network based on wireless/UWB USB. Thus, in FIG. **5**, one of the peer devices **302** or **304** initiates a request for peer-to-peer communication. The peer device **302** sends a communication request to the WLAN access point **306** or the peer device **304** sends a communication request to the WLAN access point **314** (as indicated by the thin dashed lines). The WLAN access points **306** and **314** are optically coupled to the HEU **20** by optical fibers in a fiber optic cable (as represented by the solid lines between WLAN access point **306** and the HEU **20** and between the WLAN access point **314** and the HEU **20**) such that the peer-to-peer request is sent from either the WLAN access point **306** or the WLAN access point **314** to the HEU **20**.

When the HEU **20** receives the peer-to-peer request, an optical switch bank **312** dynamically selects the appropriate optical fibers to connect the access points **308** and **310** so that the peer devices **302** and **304** associated with the access points **308** and **310** can communicate with each other. Once the optical switch bank **312** dynamically selects the appropriate optical fibers to connect the access points **308** and **310**, the peer device **302** can communicate wirelessly with the access point **308** using whatever protocol the peer device **302** and the access point **308** are capable of using, and the peer device **304** can communicate wirelessly with the access point **310** using whatever protocol the peer device **304** and the access point **310** are capable of using. In this manner, peer-to-peer communication between the peer devices **302** and **304** in different cells using different wireless protocols is enabled through the switch bank **312** establishing a dynamic optical link between the access points **308** and **310** of the two different cells.

FIG. **6** is a schematic diagram of using an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system to allow communication between peer-to-peer devices through co-existent access points according to an exemplary embodiment. In FIG. **6**, a peer device **402** is located in a different cell than a peer device **404**. The peer device **402** is capable of communicating with an access point **408** through a wireless connection (indicated by the thin dashed line on the left) when the peer device **402** is within a first cell defined by the access point **408**. The peer device **404** is capable of communicating with an access point **410** through a wireless connection (indicated by the thin dashed line on the right) when the peer device **404** is within a second cell defined by the access point **410**. The access points **408** and **410** may be coexistent access points. In one-embodiment, the access points **408** and **410** may have both WLAN and broadband (e.g. broadband-UWB) capabilities. The access points **408** and **410** are optically coupled to a HEU **20** by optical fibers in a fiber optic cable (as represented by the solid lines between the access points **408** and **410** and the HEU **20**). In the embodiment where access point **408** is a coexistent access point, a filter **409** may be used to separate broadband signals, such as 2.4 Megahertz signals, from WLAN signals, such as 802.11 signals, that may be received over the fiber optic cable from the coexistent access point **408**. In the embodiment where access point **410** is a coexistent access point, a filter **411** may be used to separate broadband signals, such as 2.4 Megahertz signals, from WLAN signals, such as 802.11 signals, that may be received over the fiber optic cable from the coexistent access point **410**. In one embodiment, the HEU **20** automatically determines that communication between the peer devices **402** and **404** are possible based on the frequency of the signals received from the peer devices **402** and **404**. In one embodiment, the HEU **20** may sense the radio frequency band content of the signals received from the peer devices **402** and **404**, with one peer device being located in each cell. The HEU **20** may then automatically determine a switch configuration by using the optical switch bank **412** to connect the cells that have common radio frequency bands via a RoF-based optical link. This automatic connection eliminates the need for a peer-to-peer request from one of the peer devices **402** or **404**, or from a third device. In one embodiment, the optical fibers may connect the access points **408** and **410** to the HEU **20** in a manner similar to that illustrated in FIGS. **2** and/or **3**. The exemplary system shown in FIG. **6** works in a similar manner as that shown in FIGS. **4** and **5**. The scenario illustrated in FIG. **6** differs from that of FIG. **5** in that only one network with coexistent capabilities is used in place of two separate networks, and that the broadband signals may be filtered from the WLAN signals. For example, the videoconferencing application example mentioned with respect to FIG. **5** would also be suitable in FIG. **6**.

When the HEU **20** receives the peer-to-peer request from either peer device **402** or **404** through the access point **408** or **410**, a switch bank **412** dynamically selects the appropriate optical fibers to connect the access points **408** and **410** so that the peer devices **402** and **404** associated with the access points **408** and **410** can communicate with each other. Once the switch bank **412** dynamically selects the appropriate optical fibers to connect the access points **408** and **410**, the peer device **402** can communicate wirelessly with the access point **408** independent of protocol. In this manner, peer-to-peer communication between the peer devices **402** and **404** in different cells using different wireless protocols is enabled through the switch bank **412** establishing a dynamic optical link between the access points **408** and **410** of the two different cells.

FIG. **7** is a schematic diagram of an exemplary embodiment of an optical switching bank at a HEU of an optically-switched fiber optic wired/wireless communication system. In FIG. **7**, fiber optic cables **702-1** through **702-*n*** and **704-1** through **704-*n*** optically couple the HEU **20** to the access point(s) of N peer devices. For example, the fiber optic cable **702-1** optically couples the HEU **20** to the access point of Peer **1** and fiber optic cable **704-*n*** optically couples the HEU **20** to the access point of Peer N. In one embodiment, each fiber optic cable **702-1** through **702-*n*** and **704-1** through **704-*n*** has a transmit optical fiber and a receive optical fiber. For example, the fiber optic cable **702-1** has an optical transmit fiber **702*t*** and an optical receive fiber **702*r***, and the fiber optic cable **704-*n*** has an optical transmit fiber **704*t*** and an optical receive fiber **704*r***. Thus, FIG. **7** illustrates how when a request for Peer **1** to communicate with Peer N is received at the HEU **20**, an optical switch bank **712** will dynamically link the two cells where Peer **1** and Peer N are located by coupling the optical transmit fiber **702*t*** and the optical receive fiber **702*r*** associated with Peer **1** to the optical receive fiber **704*r*** and the optical transmit fiber **704*t*** associated with Peer N. In one embodiment, the HEU **20** may include optical amplifiers **706**. In one embodiment, the optical amplifiers **706** may be added when it is desired to be able to enable communication between peer devices that are more than 300 meters apart.

FIG. **8** is a schematic diagram of an exemplary embodiment of using optical amplification and splitting at a HEU of an optically-switched fiber optic wired/wireless communication system for broadcasting video to peer-to-peer devices. In FIG. **8**, an incoming fiber optic cable **802** couples a device that provides a video source (not shown) to the HEU **20**. The fiber optic cable **802** may include an optical transmit fiber **802*t*** and an optical receive fiber **802*r*** in one embodiment. The HEU **20** of FIG. **8** includes a video broadcasting unit **806** that splits the video coming in over the optical transmit fiber **802*t*** to multiple outgoing fiber optic cables **804-1** to **804-*n***, each of which may be optically coupled to a peer device. Each fiber optic cable **804-1** through **804-*n*** has a transmit and a receive optical fiber. For example, the fiber optic cable **804-1** has an optical transmit fiber **804-1*t*** and an optical receive fiber **804-1*r***, and the fiber optic cable **804-*n*** has an optical transmit fiber **804-*nt*** and an optical receive fiber **804*nr***. Thus, FIG. **8** illustrates how a HEU **20** that is optically coupled to a video source may broadcast video (e.g., high-definition (HD) TV (HDTV), videoconferencing, etc.) over optical fibers to multiple peer devices in different locations. In one embodiment, the video broadcasting unit **806** may also provide amplification of the video signal. Note that in certain embodiments of the video broadcasting embodiment of FIG. **8**, not all of the optical transmit and receive fibers need be used. For example, the optical transmit fiber **802*t*** of the fiber optic cable **802**, as well as the optical transmit fibers **804-*lt*** through **804-*nt***, are not necessarily used when a video signal is broadcast using the embodiment of FIG. **8**.

FIG. **9** is a schematic diagram of an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system that illustrates an exemplary connection between a HEU and broadband transponders in two different locations. In FIG. **9**, the HEU **20** is optically coupled to broadband transponders **906** and **914**, which may be in different cellular coverage areas. Each of the broadband transponders **906** and **914** is optically coupled to the HEU **20** via a fiber optic cable **900**, which has an electrical power line **902** and one or more optical fibers **904**. The broadband transponder **906** has an RF input/output **908**, which in one embodiment is an RF antenna, a DC input/output **910**, and an optical input/output **912**. The broadband transponder **914** has an RF input/output **916**, which in one embodiment is an RF antenna, a DC input/output **918**, and an optical input/output **920**.

FIG. **10** is a schematic diagram of an exemplary embodiment of a broadband transponder that may be used in an exemplary embodiment of an optically-switched fiber optic wired/wireless communication system. FIG. **10** shows one embodiment of the broadband transponder **914** from FIG. **9** with more internal details. The broadband transponder **906** in FIG. **9** may be similar to the broadband transponder **914**. The fiber optic cable **900** having the electrical power line **902** and optical fibers **904** optically couples the broadband transponder **914** to the HEU **20** (as shown in FIG. **9**). The broadband transponder **914** may have an RF input/output **916**In and **916**Out, which in one embodiment is an RF antenna, a DC input/output **918**, and an optical input/output **920**In and **920**Out. In one embodiment, the broadband transponder **914** may also include a laser diode **922**, a photo detector **924**, and a transimpedance amplifier **926**. In one embodiment, optical switches **905** and **907** enable selections between the RF input/output **916**In and **916**Out and the optical input/output **920**In and **920**Out.

FIG. **11** is a schematic diagram of an exemplary embodiment of a HEU of an optically-switched fiber optic wired/wireless communication system. FIG. **11** illustrates the details of an exemplary HEU that can enable communication between peer devices in N cellular coverage areas. The HEU **20** shown in FIG. **11** could be used in the exemplary embodiment of an optically-switched fiber optic wired/wireless communication system shown in FIG. **5**. The HEU **20** of FIG. **11** includes a peer-to-peer request processor **1100** and optical switch bank **1102**. The peer-to-peer request processor **1100** handles the requests for communication that are received from the peer devices. Together, the peer-to-peer request processor **1100** and the optical switch bank **1102** are able to provide the high bandwidth peer-to-peer connection between peer devices in different cellular coverage areas independent of protocol. The HEU **20** can receive or transmit signals to external networks over optical fiber **1104**. A transmit optical fiber **1110** and a receive optical fiber **1112** optically couple the HEU **20** to a WLAN access point or transponder for a first peer device in a first cellular coverage area. An E/O converter unit **1106** and an O/E converter unit **1108** provide any necessary E/O or O/E conversion. A receive optical fiber **1114** and a transmit optical fiber **1116** optically couple the HEU **20** to the broadband access point or transponder for the first peer device. A receive optical fiber **1118** and a transmit optical fiber **1120** optically couple the HEU **20** to a broadband access point or transponder for a second peer device in a second cellular coverage area. A receive optical fiber **1126** and a transmit optical fiber **1128** optically couple the HEU **20** to a WLAN access point or transponder for the second peer device. An O/E converter unit **1122** and an E/O converter unit **1124** provide any necessary E/O or O/E conversion. It is to be understood that there may be additional sets of optical fibers if there are more than two peer devices.

FIG. **12** is a schematic diagram of an exemplary embodiment of a RoF-based wireless presence communication system. FIG. **12** shows one embodiment of how the RoF-based wireless presence communication system might be implemented. Each of a plurality of peer devices **1202**, **1204**, **1206**, **1208**, **1210**, **1212**, and **1214** is in a different cellular coverage area. They may be in different rooms in a building, or even on different floors in a building. In one embodiment, each of a plurality of peer devices **1202**, **1204**, **1206**, **1208**, **1210**, **1212**, and **1214** is located such that it may be capable of communicating wirelessly via both a broadband transponder and a wireless transponder, such as a WLAN, WiMax, or cellular transponder. For example, the peer device **1202** is located such that it may be located in a cellular coverage area defined by a broadband transponder **1202**B and a wireless transponder **1202**W such that peer device **1202** may be capable of communicating wirelessly via both the broadband transponder **1202**B and the wireless transponder **1202**W. Each of the other peer devices **1204**, **1206**, **1208**, **1210**, **1212**, and **1214** is also associated with a broadband transponder and a WLAN transponder such that each of the other **1204**, **1206**, **1208**, **1210**, **1212**, and **1214** may be capable of communicating wirelessly via both a broadband transponder and a wireless transponder. The solid lines indicate a typical RoF wireless deployment and the dotted lines indicate the peer-to-peer fiber connection through the nearly protocol-transparent RoF technology by using the optically-switched fiber optic wired/wireless communication system disclosed herein. The typical RoF wireless deployment connects the various rooms or cells to external networks over optical fiber **1200**, whereas the optically-switched fiber optic wired/wireless communication system disclosed herein, as shown by the dotted lines, allows room-to-room, or cell-to-cell, communication between devices in different cellular coverage areas, or between devices in the same cellular coverage area that use different communication protocols.

Thus, by using an optically-switched RoF wired/wireless communication system, the communication range of peer-to-peer communication systems may be increased. By using an optical switch bank in a HEU to set up a dynamic link between the transponders in two different cells, the devices in the two different cells can communicate with each other over the optical fibers through the HEU. This system overcomes the limitations of traditional wired/wireless peer-to-peer communications by combining the low loss, high bandwidth nature of optical fiber with an appropriate optical switching network to enhance coverage (where needed). By taking advantage of the fiber cable architecture of the optically-switched fiber optic wired/wireless communication system, such as a RoF WLAN picocell system, the peer-to-peer communication range is extended to be cell-to-cell. This means that devices in any two cells can communicate in the peer-to-peer mode independent of their physical distance, such that the peer-to-peer range extends across entire indoor installation areas. In addition, the optically-switched fiber optic wired/wireless communication system disclosed herein uses optical cable links that are nearly transparent to wireless protocols, thereby eliminating proprietary protocol compliance requirements.

Further, as used herein, it is intended that the terms "fiber optic cables" and/or "optical fibers" include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. An example of a bend-insensitive optical fiber is ClearCurve® Multimode fiber commercially available from Corning Incorporated.

Many modifications and other embodiments set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover any modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A wireless communication system, comprising:

an optical switch bank;

a plurality of remote access points distributed throughout multiple floors of a building infrastructure; and

at least one fiber optic cable, the at least one fiber optic cable comprising a plurality of optical fibers and being configured to carry Radio-over-Fiber (RoF) signals from the optical switch bank for communication with the remote access points, wherein

a first one of the plurality of remote access points is configured to form a corresponding first coverage area,

a second one of the plurality of remote access points is configured to form a corresponding second, different coverage area,

the optical switch bank is configured to establish a RoF-based optical link over at least one of the fiber optic cables such that a first peer device in the first coverage area can communicate with a second peer device in the second coverage area at least in part over the RoF-based optical link, and

at least one of the first and second ones of the plurality of remote access points is configured to communicate via both Wireless Local Area Network (WLAN) and broadband signals.

2. The wireless communication system of claim **1**, wherein the at least one optical fiber cable includes thirty-six optical fibers, and wherein the first one of the plurality of remote access points is configured to wirelessly communicate with the first peer device using a different wireless communication protocol than a protocol used by the second one of the plurality of remote access points to wirelessly communicate with the second peer device.

3. The wireless communication system of claim **1**, wherein

the first one of the plurality of remote access points is configured to wirelessly communicate with the first peer device; and

the second one of the plurality of remote access points is configured to wirelessly communicate with the second peer device.

4. The wireless communication system of claim **3**, wherein the system is configured to automatically establish the RoF-based optical link between the first coverage area and the second coverage area when signals received from the first peer device in the first coverage area and signals received from the second peer device in the second coverage area have common radio frequencies.

5. The wireless communication system of claim **4**, further comprising at least one WLAN access point configured to receive a request from a device other than the first and second peer devices to establish communications between the first and second peer devices.

6. The wireless communication system of claim **3**, further comprising at least one WLAN access point configured to receive a request from a device other than the first and second peer devices to establish communications between the first and second peer devices.

7. The wireless communication system of claim **6**, wherein the at least one optical fiber cable includes thirty-six optical fibers and comprises at least one riser cable.

8. The wireless communication system of claim **3**, wherein the first one of the plurality of remote access points is configured to wirelessly communicate with the first peer device using a different wireless communication protocol than a protocol used by the second one of the plurality of remote access points to wirelessly communicate with the second peer device.

9. The wireless communication system of claim **3**, wherein at least one of the plurality of remote access units further comprises at least one of a radio frequency (RF) input/output, a DC input/output, and an optical input/output.

10. The wireless communication system of claim **9**, wherein the at least one optical fiber cable includes thirty-six optical fibers and comprises at least one riser cable.

11. The wireless communication system of claim **1**, wherein the at least one optical fiber cable includes thirty-six uplink optical fibers and comprises at least one riser cable, and wherein the optical switch bank dynamically selects an appropriate optical fiber so that the first peer device can communicate with a second peer device.

12. The wireless communication system of claim **11**, wherein the optical switch bank is located at a head-end unit (HEU), the HEU being configured to receive a request from the first peer device to communicate with a second peer device via at least one WLAN access point.

13. The wireless communication system of claim **12**, wherein the HEU further comprises a video broadcast unit configured to split a video signal received at the HEU.

14. The wireless communication system of claim **1**, wherein the at least one optical fiber cable includes thirty-six optical fibers, and wherein the system is configured to automatically establish the RoF-based optical link between the first coverage area and the second coverage area when signals received from the first peer device in the first coverage area and signals received from the second peer device in the second coverage area have common radio frequencies.

15. A wireless communication system, comprising:

an optical switch bank;

a plurality of remote access points distributed throughout multiple floors of a building infrastructure; and

at least one fiber optic cable, the at least one fiber optic cable comprising a plurality of optical fibers and being configured to carry Radio-over-Fiber (RoF) signals from the optical switch bank for communication with the remote access points, wherein

a first one of the plurality of remote access points is configured to form a corresponding first coverage area,

a second one of the plurality of remote access points is configured to form a corresponding second, different coverage area,

the optical switch bank is configured to establish a RoF-based optical link over at least one of the fiber optic cables such that a first peer device in the first coverage area can communicate with a second peer device in the second coverage area at least in part over the RoF-based optical link,

at least one of the first and second ones of the plurality of remote access points is configured to communicate via at least one of Wireless Local Area Network (WLAN) and broadband signals,

the at least one optical fiber cable includes thirty-six optical fibers, and

the system is configured to automatically establish the RoF-based optical link between the first coverage area and the second coverage area when signals received from the first peer device in the first coverage area and signals received from the second peer device in the second coverage area have common radio frequencies.

16. The wireless communication system of claim **15**, the at least one fiber optic cable includes at least one riser cable.

17. The wireless communication system of claim **16**, the at least one fiber optic cable includes uplink cables and downlink cables.

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